

***In vitro* comparison of different types of sodium perborate used for intracoronar bleaching of discoloured teeth**

H. Ari¹ & M. Üngör¹

¹Selcuk University Faculty of Dentistry, Department of Endodontics, Konya, Turkey

Abstract

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Aim To compare the bleaching efficacy of three different types of sodium perborate (SP) commonly used for intracoronar bleaching of discoloured non-vital teeth.

Methodology Sixty-five extracted human maxillary central incisors with intact crowns were used. Following obturation with gutta-percha and a root canal sealer using a lateral condensation technique, the coronal aspects of the root canal fillings were covered with a 1-mm thick protective base placed to a level 1 mm apical to the labial cemento–enamel junction (CEJ). The teeth were then stained artificially with fresh blood over a period of 18 days. One or other of the bleaching materials (group 1: SP monohydrate + water, group 2: SP trihydrate + water, group 3: SP tetrahydrate + water, group 4: SP monohydrate + hydrogen peroxide (HP), group 5:

SP trihydrate + HP, group 6: SP tetrahydrate + HP) were placed in the pulp chamber of the discoloured teeth and sealed with Cavit for 21 days. They were replaced with fresh preparations after 3, 7 and 14 days. The shades of the tooth crowns were evaluated at baseline and at 7, 14 and 21 days. Comparison of tooth shades was completed at each interval and analysed statistically using the chi-squared test.

Results There was no statistically significant difference between the groups at 7, 14, 21 days. Period of bleaching significantly affected the outcome ($P < 0.01$). No colour changes were noted in the control teeth.

Conclusion The data obtained from this study demonstrate that sodium perborate can be used mixed with water rather than with hydrogen peroxide for bleaching discoloured teeth.

Keywords: hydrogen peroxide, intracoronar bleaching, sodium perborate.

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Introduction

Discolouration of non-vital teeth can occur through extrinsic and/or intrinsic factors. Amongst the intrinsic stains, intrapulpal haemorrhage and/or pulp necrosis, often associated with impact injuries of teeth, can be successfully managed using intracoronar bleaching (Ingle & Bakland 1994).

Bleaching of discoloured non-vital teeth offers some advantages over more radical treatment such as full coverage restorations, since little tooth structure is lost and the cost of treatment is minimal. The most commonly

used intracoronar bleaching materials are an aqueous solution of 30% hydrogen peroxide and sodium perborate. These materials may be used either separately or in combination. Bleaching techniques include the thermocatalytic method, walking bleach and combined method. In the thermocatalytic technique a heat source is used to activate the bleaching agent placed in the pulp chamber through the release of nascent oxygen (Walton & Torabinejad 1996).

In the walking bleach technique, a thick paste of sodium perborate mixed with hydrogen peroxide or water is placed in the pulp chamber and sealed for periods of 3 to 7 days (Walton & Torabinejad 1996). Spasser (1961) appears to have been the first to suggest the use of sodium perborate and water mixed to a paste for intracoronar bleaching. Nutting & Poe (1963) substituted

Correspondence: Dr Hale Ari, Selcuk University Faculty of Dentistry, Department of Endodontics, 42079-Konya, Turkey (fax: +90 332241 00 62; e-mail: Hale29tr@yahoo.com).

water for hydrogen peroxide to achieve synergism and a more rapid bleaching effect. However, external cervical root resorption has been reported to occur following intracoronary bleaching of discoloured pulpless teeth with the walking bleaching technique when hydrogen peroxide was used (Harrington & Natkin 1979, Latcham 1986, Friedman *et al.* 1988). Therefore, it is recommended that sodium perborate should be used mixed with water rather than hydrogen peroxide in order to prevent or minimize the occurrence of bleaching-related external root resorption (Holmstrup *et al.* 1988, Rotstein *et al.* 1991, Weiger *et al.* 1994).

Sodium perborate is a white crystalline odourless powder and occurs in a variety of forms depending on the content of water of crystallization. Sodium perborate monohydrate (MH), trihydrate (TRH) and tetrahydrate (TH) are available. However, these commonly used terms do not reflect the real chemical structure of sodium perborate compounds. No water of crystallization is present in the case of the so called MH, whilst in TH six water molecules are connected to the sodium perborate ring (Weiger *et al.* 1994).

The aim of this study was to compare the *in vitro* bleaching efficacy of three different types of sodium perborate commonly used for intracoronary bleaching of discoloured non-vital teeth, mixed either with water or hydrogen peroxide.

Materials and methods

Sixty-five human maxillary incisors with intact crowns were used. After extraction, all soft tissues and debris covering the root surfaces was removed with scalers and the teeth immersed in 5% sodium hypochlorite for 1 h. After this the teeth were stored in physiological saline. The root canal of each tooth was accessed and then enlarged using a step-back technique followed by obturation with gutta-percha and a root canal sealer (Grossman, Sultan-U/P, Englewood, NJ, USA) using lateral condensation. Coronally, the root canal filling was reduced and then covered with a 1-mm thick protective base (ZnPO_4 , Adhesor, Spofa Dental, Prague, Czech Republic) placed to a level, 1 mm apical to the buccal cemento–enamel junction. Any remnants of root filling or base material covering the walls of the access cavity were removed completely with a small carbide bur, followed by rinsing with 5% NaOCl and 17% EDTA. All teeth were stained with fresh red blood cells using a method similar to that described by Freccia & Peters (1982). Each tooth was placed in an individual plastic test tube containing 2 mm fresh human blood and then centrifuged at 10 000 r.p.m. for

30 min, three times a day. The blood was replaced each day and the discolouration procedure repeated for 18 consecutive days, until adequate discolouration was achieved in all teeth. The teeth were finally washed with distilled water and the crowns polished with a rubber cup and pumice.

The teeth were randomly divided into six experimental groups of 10 teeth each and a control group of five teeth (Table 1).

After removing the smear layer in the access opening with 17% EDTA and 5% NaOCl, identical volumes of one or other of the bleaching pastes were placed into the pulp chamber of each experimental tooth. The access cavities were sealed with Cavit (Espe, Seefeld, Germany). The teeth were then stored at 100% humidity and 37°C.

In the control group, a cotton pellet was inserted instead of a bleaching paste. The purpose of using the control group was to demonstrate the effectiveness of the artificial staining and to determine that bleaching on experimental groups was directly related to the experimental conditions.

As bleaching agents, sodium perborate mixed with 30% hydrogen peroxide or bidistilled water in a ratio of 2 g of powder to 1 mL of liquid was used. Sodium perborate was available as MH (Degussa, Hanau, Germany), TRH (Merck, Darmstadt, Germany) and TH (Degussa). The corresponding chemical formulas and some of the physicochemical data of MT, TRH and TH are listed in Table 2.

During the experiment, the pulp chamber was refilled with fresh bleaching paste at days 3, 7 and 14. The access cavities were sealed with Cavit. Throughout the procedure, the crowns of teeth were kept wet with gauze soaked with water.

Standardized colour images of the buccal aspect of all crowns were recorded on computer using a flat scanner (Mustec Pro, USA) at the same resolution and standard conditions before the discolouration procedure (baseline), immediately after artificial staining at days 7, 14 and 21. All the recorded images were first viewed on the screen and then comparatively evaluated. The shade of

Table 1 Bleaching agents evaluated

Groups	n	Bleaching agents
1	10	Monohydrate + water ($\text{MH} + \text{H}_2\text{O}$)
2	10	Trihydrate + water ($\text{TRH} + \text{H}_2\text{O}$)
3	9	Tetrahydrate + water ($\text{TH} + \text{H}_2\text{O}$)
4	10	Monohydrate + hydrogen peroxide ($\text{MH} + \text{H}_2\text{O}_2$)
5	10	Trihydrate + hydrogen peroxide ($\text{TRH} + \text{H}_2\text{O}_2$)
6	10	Tetrahydrate + hydrogen peroxide ($\text{TH} + \text{H}_2\text{O}_2$)
7	5	No (control)

Table 2 Comparison of sodium perborate monohydrate, trihydrate and tetrahydrate

Sodium perborate	Monohydrate	Trihydrate	Tetrahydrate
Old formula	$\text{NaBO}_3 \cdot \text{H}_2\text{O}$	$\text{NaBO}_3 \cdot 3\text{H}_2\text{O}$	$\text{NaBO}_3 \cdot 4\text{H}_2\text{O}$
Correct formula	$2 \times \text{NaBO}_2 \cdot (\text{OH})_2$	$2 \times [\text{NaBO}_2(\text{OH})_2] \cdot 4\text{H}_2\text{O}$	$2 \times [\text{NaBO}_2(\text{OH})_2] \cdot 6\text{H}_2\text{O}$
Content of active oxygen (%)	16.0	11.8	10.4
Solubility in water (20°C)	15 g l ⁻¹	–	23 g l ⁻¹

Table 3 The number of specimen by degree of shade change for each group at days 7, 14 and 21

	MH-W	TRH-W	TH-W	MH-HP	TRH-HP	TH-HP
<i>Day 7</i>						
Degree 1	5	7	6	4	4	3
Degree 2	5	3	4	5	5	6
Degree 3	–	–	–	1	–	1
<i>Day 14</i>						
Degree 1	–	2	–	–	–	–
Degree 2	6	7	6	3	5	4
Degree 3	4	1	4	7	4	6
<i>Day 21</i>						
Degree 1	–	–	–	–	–	–
Degree 2	1	3	2	–	3	3
Degree 3	9	7	8	10	6	7

crowns was compared by the same examiner at identical periods to a Vita (Rauter GmbH & Co, Bad Söcking, Germany) shade guide that was also recorded under the same conditions. A similarity was observed amongst the screen records and Vita shade records. During these subjective evaluations, bleaching efficacy was categorized from degrees 1–3 as listed below:

Degree 1: no or a slight bleaching.

Degree 2: a clearly visible bleaching.

Degree 3: a complete or nearly complete bleaching indicating that the discoloured tooth had returned to its original shade.

Statistical analysis was performed using the chi-squared test.

Results

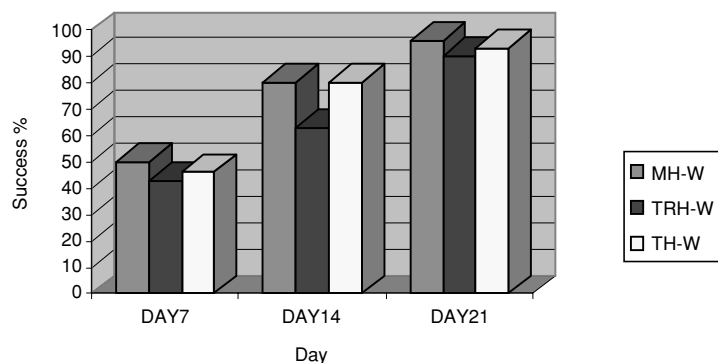
The results of the six bleaching preparations are shown in Table 3. A comparison of the bleaching success rate of the groups at each interval is provided in Figures 1 and 2. Successful bleaching was accomplished when the treated tooth had gained its original or a lighter shade.

No colour changes were noted in the control teeth. No statistically significant differences occurred between the treatment groups. Significant differences occurred between the bleaching times ($P < 0.01$).

Discussion

In this study, the effect of three different types of sodium perborate mixed with water or hydrogen peroxide on intracoronary bleaching was determined in artificially discoloured human teeth. This method was used because it simulates the most common cause of tooth discolouration. When the pulp is injured, blood extravasation from ruptured vessels may invade the pulp chamber and erythrocytes can penetrate the dentinal tubules. The erythrocytes undergo haemolysis and liberate haemoglobin, which releases iron. The iron is combined with hydrogen sulphide to form iron sulphide, a black compound that gives the tooth its dark discolouration (Grossman 1978).

Caution must be exercised when applying the results of this *in vitro* study to clinical conditions. The following factors should be taken into consideration; first, tooth

**Figure 1** Percentage of successfully bleached teeth in water groups at days 7, 14 and 21.

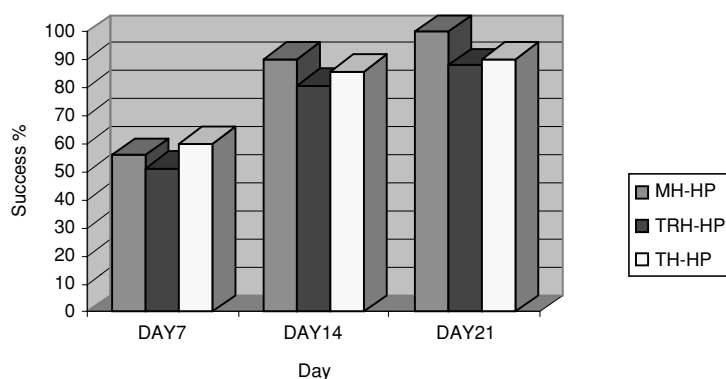


Figure 2 Percentage of successfully bleached teeth in HP groups at days 7, 14 and 21.

discoloration caused by blood decomposition is usually easier to remove than that caused by other factors; the discolouration produced in this study was a result of pure erythrocytic decomposition. Clinically, necrotic pulp tissue and bacterial by-products may also contribute to the discolouration process. Therefore, the present results may not be applied to all types of tooth discolouration. Secondly, bleaching is more likely to be successful in recently stained teeth than in these with a long standing discolouration (Brown 1965). The discolouration produced in this study occurred over 18 days. In other studies using similar techniques this period was shorter and did not exceed 1 week (Ho & Goering 1989, Warren *et al.* 1990).

Although the three types of sodium perborate are available, the tetrahydrate type is used commonly in walking bleaching techniques (Rotstein *et al.* 1991). Weiger *et al.* (1994) also used three different types of sodium perborate and showed that, although the monohydrate had the highest content of active oxygen, there was no significant difference between them.

Conclusion

All three sodium perborate combinations yielded similar results at the end of the experimental period. Thus, sodium perborate should be mixed with water rather than with hydrogen peroxide in order to prevent or minimize the occurrence of bleaching-related external root resorption.

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